Simultaneous Direct Heat and Carbon Dioxide Flux at a Turbulent Free Surface

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Turbulence enhances both heat and CO_2 gas exchange at a free surface. At the air-water interface, heat and mass transport occurs within a thin thermal/diffusive boundary layer. The turbulence acts to thin the heat and mass boundary layers, thereby mixing the cool surface water and high concentration CO_2 water into the bulk. This surface water is replaced with warmer, lower concentration CO_2 water. Because of their codependence, there is strong evidence to suggest a relationship between the two types of transfer. Using a laboratory tank, which generates turbulence with no mean shear flow, we studied heat and mass transfer by capturing infrared imagery to map the two-dimensional surface temperature and using laser induced fluorescence (LIF) to map the two-dimensional subsurface CO_2 flux. In addition, particle image velocimetry (PIV) generated subsurface velocity fields. The result was a time series of quantitative imagery that we used to analyze and quantify the two different transports. Preliminary comparative analysis showed strong evidence for the existence of a relationship and further analysis was performed. The sub-surface analysis was performed by Evan Variano at the Defrees Hydraulics laboratory at Cornell University. This paper aims to quantify the surface measurements and describes the integral length scale analysis of the infrared imagery. Using this process we were able to calculate the autocorrelation function and the characteristic length of turbulent events at the surface. This analysis enabled us to effectively identify periods of heavy turbulent mixing at the surface and revealed the localized nature of such events. Further, we were able to lay the groundwork for future integral time scale analysis and covariance estimates of heat and mass flux. Eventually the surface and subsurface results will be compared in order to increase our understanding of turbulent transport across the air-sea interface.